TECHNICAL MEMORANDUM
DECOMMISSIONING OF THE CARBON DIOXIDE SPARGE WELL NETWORK
LCP CHEMICALS SUPERFUND SITE – BRUNSWICK, GEORGIA

Date:	March 2, 2021
To:	Mr. Robert H. Pope, Senior Remedial Project Manager, U.S. EPA Region IV, Superfund and Emergency Management Division
From:	Kirk Kessler, P.G., Environmental Planning Specialists, Inc.
Copy:	Prashant Gupta, Honeywell

INTRODUCTION

Honeywell entered into an Administrative Order of Consent ("AOC") which was entered into between Honeywell and the United States Environmental Protection Agency ("EPA") on April 18, 2007, to perform a removal response action for a condition known as the Caustic Brine Pool ("CBP") at the LCP Chemicals Superfund Site located in Brunswick, Georgia (the "Site"). The term CBP was devised to bound an altered groundwater geochemical condition resulting from a comingled release of chlor-alkali process liquids (caustic and brine) from the cell building area (CBA).[1] The objectives under the AOC for conducting the sparging were to: 1) reduce the pH of the CBP to between 10 and 10.5; and 2) reduce the density of the CBP.

Honeywell performed a series of CBP treatments over a period from November 2013 to August 2019 using *in situ* sparging of CO_2 gas, which through chemical reaction produced carbonic acid facilitating neutralization of the elevated pH condition. In total, 267 sparge wells were utilized during the four phases of geographic expansion of the sparge well network (Figure 1). The injection of CO_2 achieved the two principal remedial action objectives of the AOC across the treatment footprint: reduce groundwater pH to below 10.5, and reduce groundwater specific gravity (Mutch, 2020). This achievement was recognized in a letter from EPA to Honeywell dated June 23, 2020, and further reinforced by subsequent additional groundwater monitoring completed in August 2020 related to the Remedial Investigation for Operable Unit 2 ("OU2").

Considering the above (and as further supported by more detailed information below), Honeywell proposes decommissioning of the sparge well network and piezometers as described herein.

[1] The CBA is the area of former chlor-alkali manufacturing operation located south of B-Street. Two sister buildings at this location designated Cell Building 1 (north building) and Cell Building 2 (south building) each contained an independent mercury cell process supported by a salt purification plant and additional on-Site holding tanks for process liquids.

Chemistry of the CO_2 Treatment

The chemical behavior of aqueous systems, including the geochemical impact of CO_2 gas dissolution into groundwater, is governed by an elaborate set of mass action laws that define the distribution of solutes at a state of equilibrium (*i.e.*, equilibrium relationships) and conservation equations describing a concentration and an electroneutrality condition. In elevated pH environments, such as characteristic of the CBP, CO_2 dissolved in water ("aqueous CO_2") reacts directly with hydroxide ion (OH^-) to form bicarbonate ion (HCO_3^-). This reaction becomes increasingly thermodynamically unfavorable as the consumption of OH^- drives the pH toward a neutral condition. Thereafter, the hydration of CO_2 leads to the formation of carbonic acid (H_2CO_3), which dissociates into HCO_3^- and further dissociates into carbonate ion (CO_3^{2-}). The dissociation of H_2CO_3 and HCO_3^- results in the liberation of protons and a corresponding decrease in pH.

Heterogeneities and preferential flow paths in the subsurface cause an uneven distribution of CO_2 gas, resulting in small pockets of untreated groundwater. Over time, natural processes of physical mixing and dilution within the aquifer homogenize the residual condition and larger treated groundwater volume, with a net result of a pH condition that closely resembles that of the treated groundwater. Note, the primary driving mechanism of the high pH condition (*i.e.*, caustic addition) has been eliminated due to cessation of plant operations in February 1994 and subsequent removal action on the upland portion of the Site (1994-1997), which addressed chlor-alkali process waste disposal areas (*e.g.*, brine mud impoundments). Thus, no mechanism exists to cause groundwater pH to rebound to the pre-treatment condition.

Phases of Treatment and Associated Well Installations (Figure 1)

Proof of Concept (i.e., Pilot Test): October 2012 – November 2012

CBP treatment began with a "proof-of-concept" field trial in the Fall of 2012 in the area of monitoring well cluster MW-115. One sparge well and seven CBP treatment monitoring wells (MW-1 to -3 series) were installed. The test proved to be successful supporting a broader scale design for the first phase of full-scale treatment.

Phase 1: October 2013 – February 2014

Phase 1 involved installation of 64 sparge wells on approximate 80-ft spacing, and installation of 15 piezometers (for water-level and pressure monitoring). Geoprobe groundwater sampling was conducted along the southern border of the CBP as mapped in 2012, over the period of July – August 2014 to refine the delineation of the CBP in support of the next phase of work.

Phase 2: October 2014 – April 2015

Phase 2 involved installation of 58 sparge wells within the Phase 1 footprint, and another 21 sparge wells bordering the footprint mainly to the south where the Geoprobe sampling indicated a broader presence of the CBP plume. Twenty additional piezometers were installed for Phase 2.

Phase 3: October 2015 – May 2016

Additional geoprobe groundwater sampling was performed along the western edge of the Phase 1-2 sparging footprint to delineate the outer edge of the pH 10.5 plume. Phase 3 involved installation of another 65 sparge wells within the Phase 1-2 footprint and areas bordering including portions of the western margin. A comprehensive report of Phases 1-3 was prepared in July 2016 (Mutch, 2016). One year later at the request of the EPA, a site-wide groundwater sampling event was performed for OU2 (September – October 2017) that also served the purpose of a 1-year post-treatment CBP monitoring event for assessing potential rebound of the pH condition. A Technical Memorandum was prepared in March 2018 following this sampling event presenting and concluding no appreciable rebound of pH had occurred within the sparging footprints, and that total dissolved solids (*i.e.*, density) had decreased from pre-Phase 1 to post-Phase 3 (Mutch, 2018).

Phase 4: May 2019 – August 2019

On May 10, 2018, EPA issued a letter requesting a workplan for additional work to be performed involving characterization of the CBP condition within the CBA (an area not involved in the Phase 1-3 CO_2 treatment). Characterization work was performed in December 2018 with supplemental characterization in January 2019 to refine the CBP delineation in this remaining area of the Site. This supported the preparation of a Technical Memorandum in February 2019 providing the design layout of the Phase 4 sparging, involving installation of 58 new sparge wells (Mutch, 2019). Sparging was performed in the 58 newly installed sparge wells and bordering Phase 1-3 sparge wells over the period of May – August 2019. A monitoring event was performed in September 2019 involving all of the Phase 4 sparge wells and nearby monitoring wells, reported in a June 2020 Technical Memorandum (Mutch, 2020). A subsequent monitoring event was performed in August 2020 involving monitoring wells across OU2 as well as the CBA, with results provided in a comprehensive OU2 Data Package dated October 15, 2020 (EPS, 2020).

Response of Site Groundwater pH Condition to CO_2 Treatment (Figures 2a-c)

The effect of the CO_2 treatment on groundwater pH is illustrated for each hydrogeologic setting of the Satilla (*i.e.*, upper Satilla, middle Satilla, and lower Satilla) in Figures 2a-2c, respectively. Groundwater pH has been reduced to a neutral ($6<pH<8$) or mildly alkaline condition ($8<pH<10.5$) at all monitoring well points within the footprint of the CBP treatment. An illustrative example of the re-equilibration of the pH condition at pocket locations of residual elevated pH is provided by monitoring well location MW-361B, installed in Phase 4 approximately equidistant between four surrounding sparge wells. The well was first sampled in January 2019 and again in April 2019 prior to Phase 4 sparging. At that time, the pH condition was 10.3 – 10.4. Sampling was then performed in September 2019 following Phase 4 sparging, and the pH condition persisted (10.8). Sampled again approximately one year later in August 2020, the pH condition was circumneutral (7.0) consistent with the overall general condition following treatment. Time trend graphs for monitoring well points within the footprint illustrate that the pH reduction has persisted with no rebound several years after the CO_2 injections ceased (Attachment 1), confirming the stability of the condition.

Recommendation (Figure 3)

The science and abundance of empirical data support the decommissioning of the sparge well network as the removal action objectives from the AOC have been met, and the condition has proven to be stable over time. Decommissioning will also involve the piezometers[2], which no longer serve a useful purpose.

References

[EPS] Environmental Planning Specialists, Inc (2020). "LCP Chemical Site Operable Unit 2, 2020 Groundwater Sampling Event Data Package." October 15.

[Mutch] Mutch and Associates (2016). "CO_2 Sparging Phase 3 Full-Scale Implementation and Monitoring Report. LCP Chemicals Site, Brunswick, Georgia." July 14.

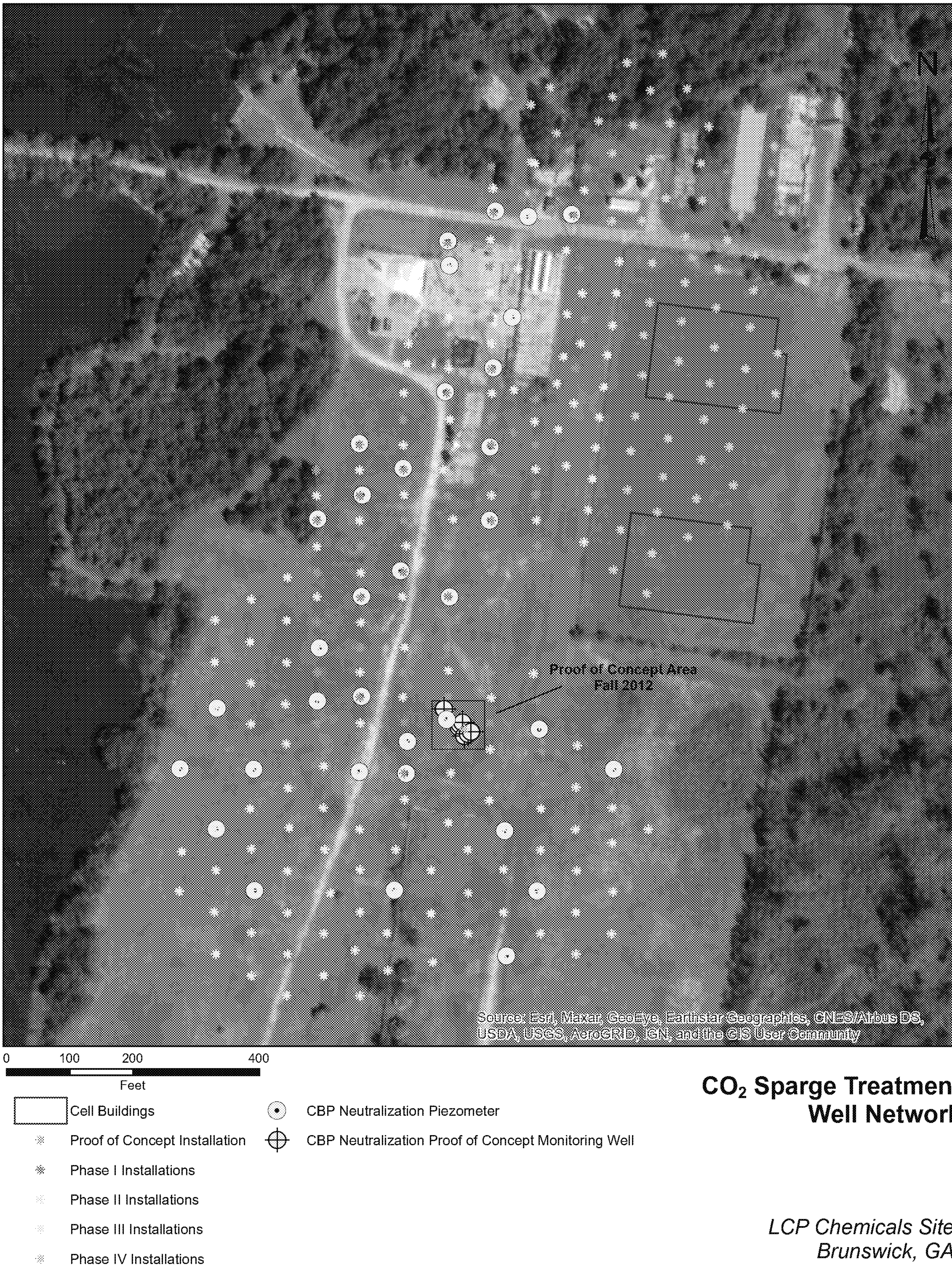
Mutch (2018). "Technical Memorandum, Update on Water Quality After CO2 Sparging, LCP Chemicals Site, Brunswick, Georgia." March 8.

Mutch (2019). "CO_2 Sparging Phase 4 Full-Scale Implementation and Monitoring Report. LCP Chemicals Site, Brunswick, Georgia." Revision 1, June.

Mutch (2020). "CO_2 Sparging Phase 4 Full-Scale Implementation and Monitoring Report. LCP Chemicals Site, Brunswick, Georgia." Revision 1, June.

[2] In addition to piezometers installed specific to the CO_2 injection monitoring, other remnant piezometers (for activity prior to the CBP treatment) exist in the same vicinity which are planned for decommissioning.

FIGURES

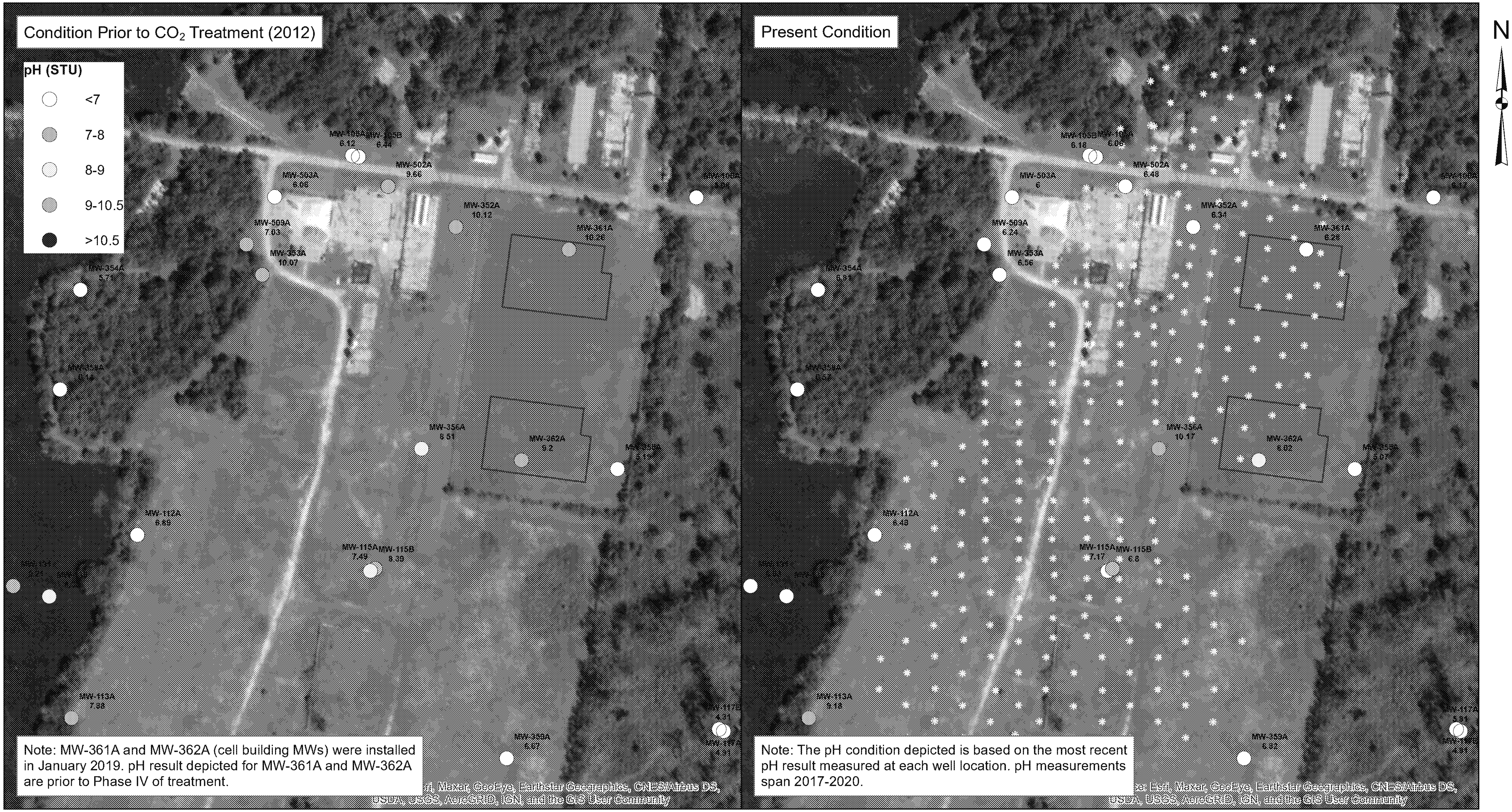


CO_2 Sparge Treatment Well Network

LCP Chemicals Site
Brunswick, GA

Environmental Planning Specialists, Inc.

Figure No. 1



0 200 400
Feet

Cell Buildings

Sparge Wells

Groundwater pH Condition Response to In Situ CO_2 Treatment: Upper Satilla

LCP Chemicals Site
Brunswick, GA

Environmental Planning Specialists, Inc.

Figure No. 2a

0 200 400

Feet

Cell Buildings

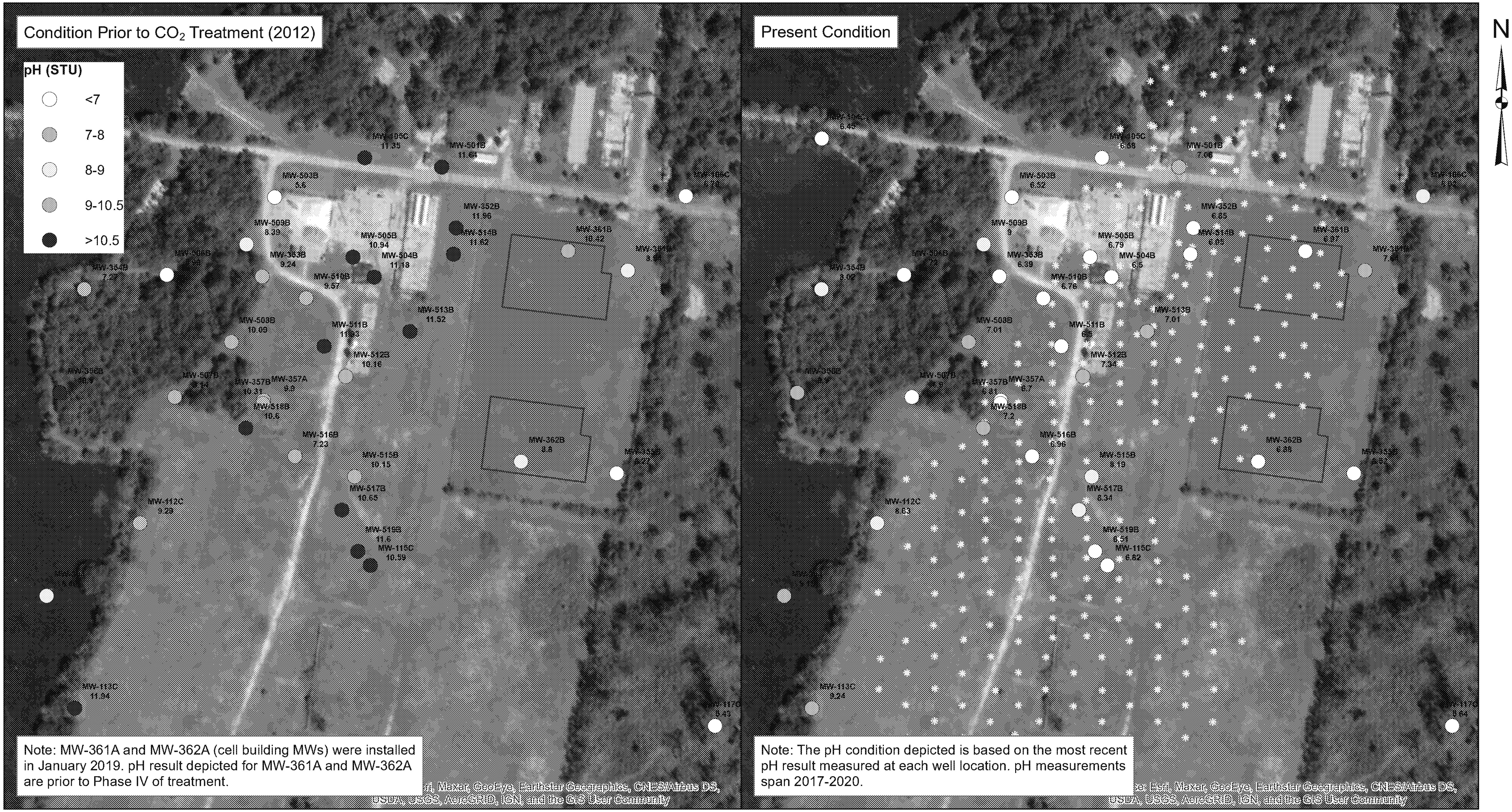
Sparge Wells

Groundwater pH Condition Response to In Situ CO_2 Treatment: Middle Satilla

LCP Chemicals Site
Brunswick, GA

Environmental Planning Specialists, Inc.

Figure No. 2b



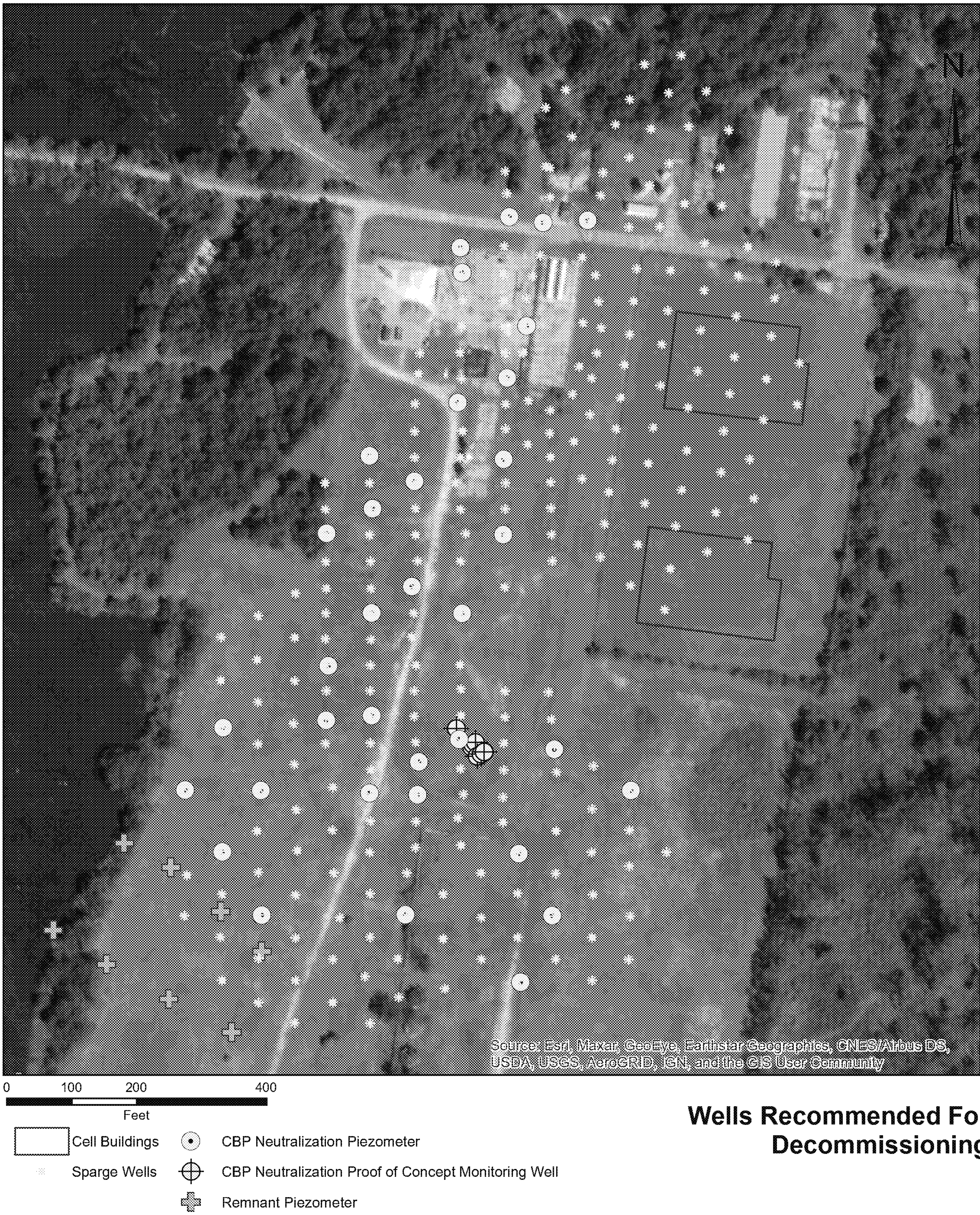
0 200 400
Feet

Cell Buildings

Sparge Wells

Groundwater pH Condition Response to In Situ CO_2 Treatment: Lower Satilla

LCP Chemicals Site
Brunswick, GA



Wells Recommended For Decommissioning

Note:
(1) Wells shaded gray are recommended for decommissioning.

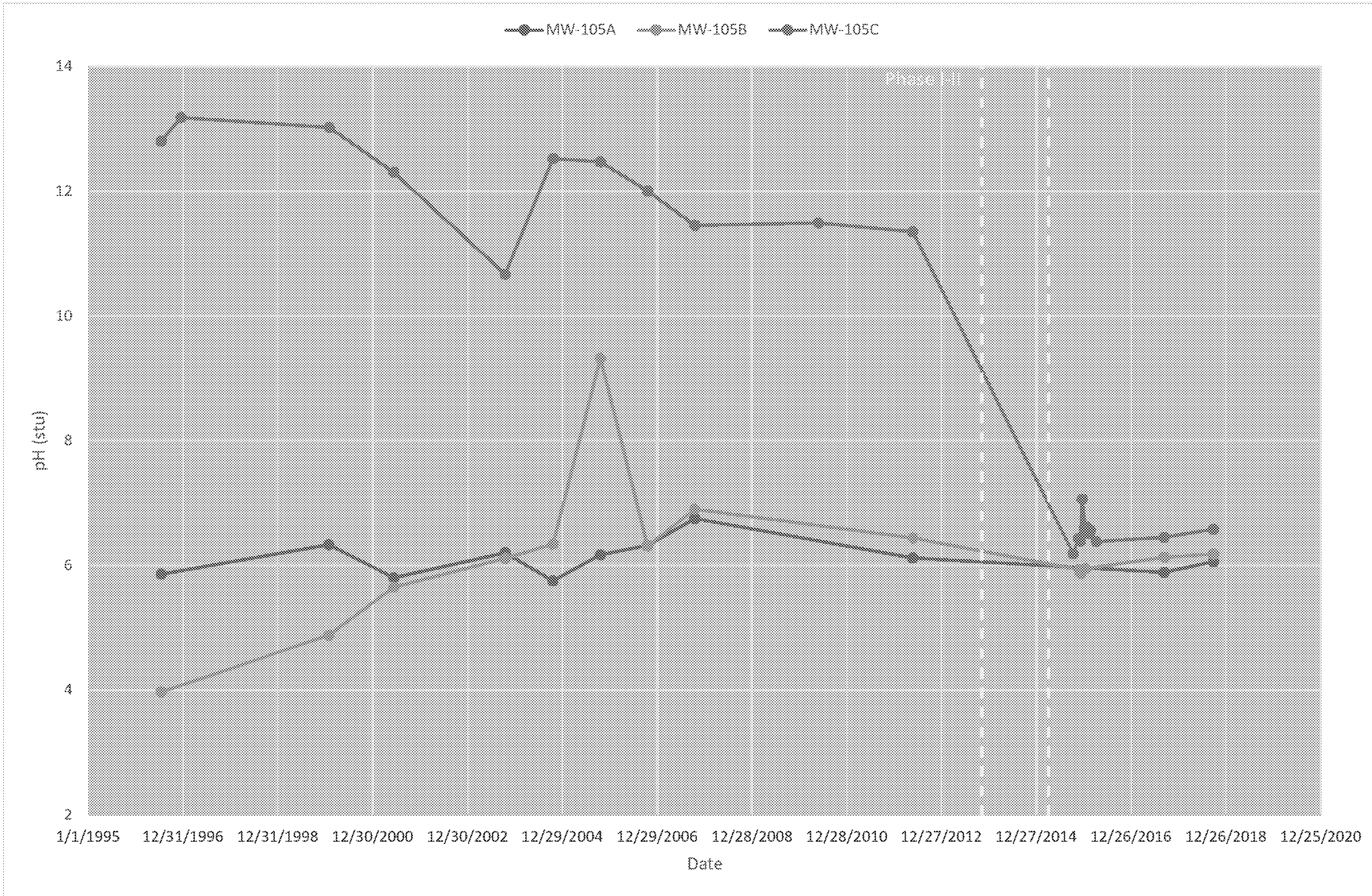
LCP Chemicals Site
Brunswick, GA

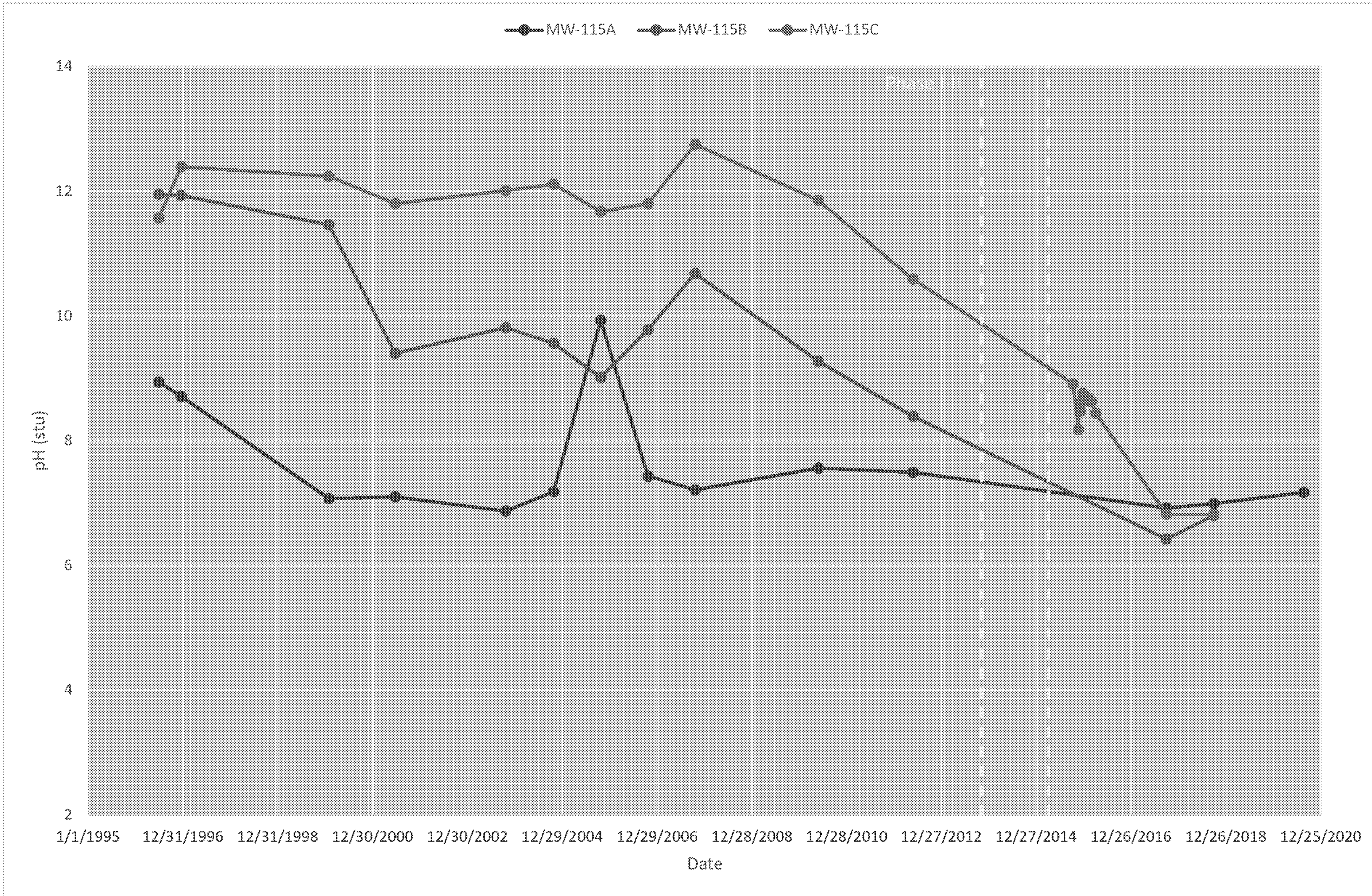
Environmental Planning Specialists, Inc.

Figure No. 3

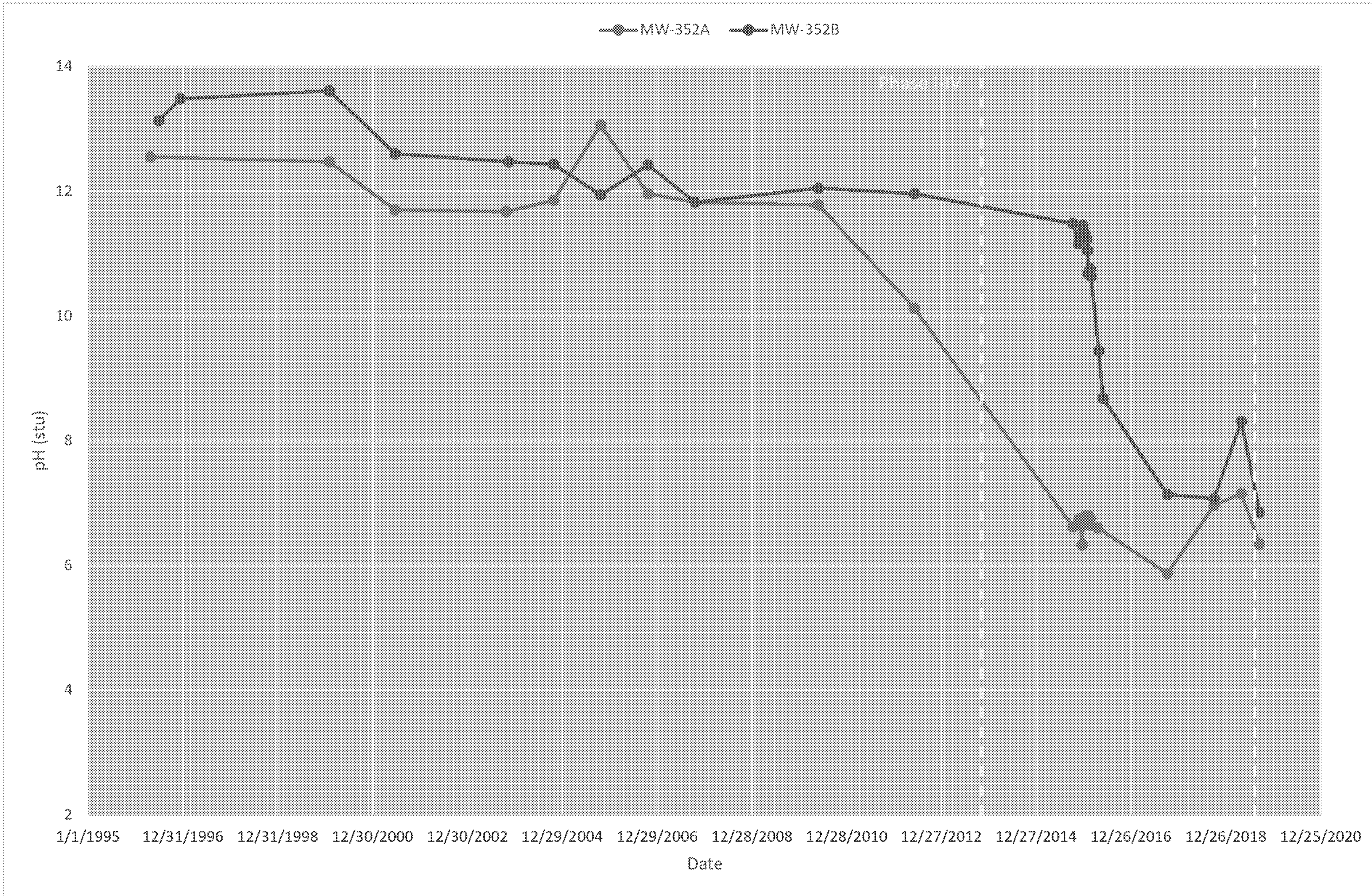
Attachment 1

Time Trend Graphs


MW-105A
MW-105B
MW-105C
Phase I-II
pH (stu)
14
12
10
8
6
4
2
1/1/1995
12/31/1996
12/31/1998
12/30/2000
12/30/2002
12/29/2004
12/29/2006
12/28/2008
12/28/2010
12/27/2012
12/27/2014
12/26/2016
12/26/2018
12/25/2020
Date



MW-115A
MW-115B
MW-115C
Phase I-II
14
12
10
8
6
4
2
pH (stu)
1/1/1995
12/31/1996
12/31/1998
12/30/2000
12/30/2002
12/29/2004
12/29/2006
12/28/2008
12/28/2010
12/27/2012
12/27/2014
12/26/2016
12/26/2018
12/25/2020
Date



MW-352A
MW-352B
Phase I-IV
pH (stu)
14
12
10
8
6
4
2
1/1/1995
12/31/1996
12/31/1998
12/30/2000
12/30/2002
12/29/2004
12/29/2006
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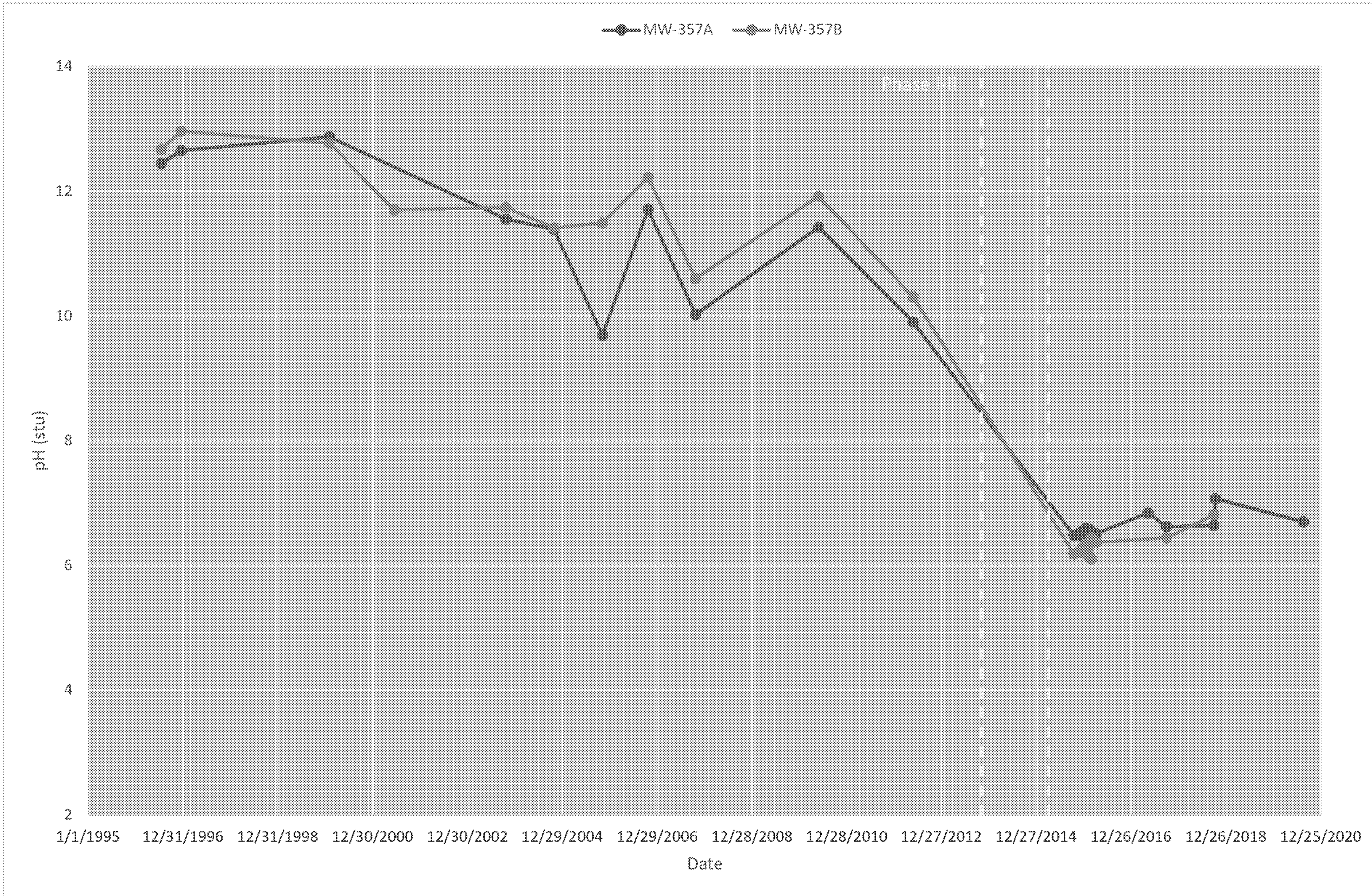
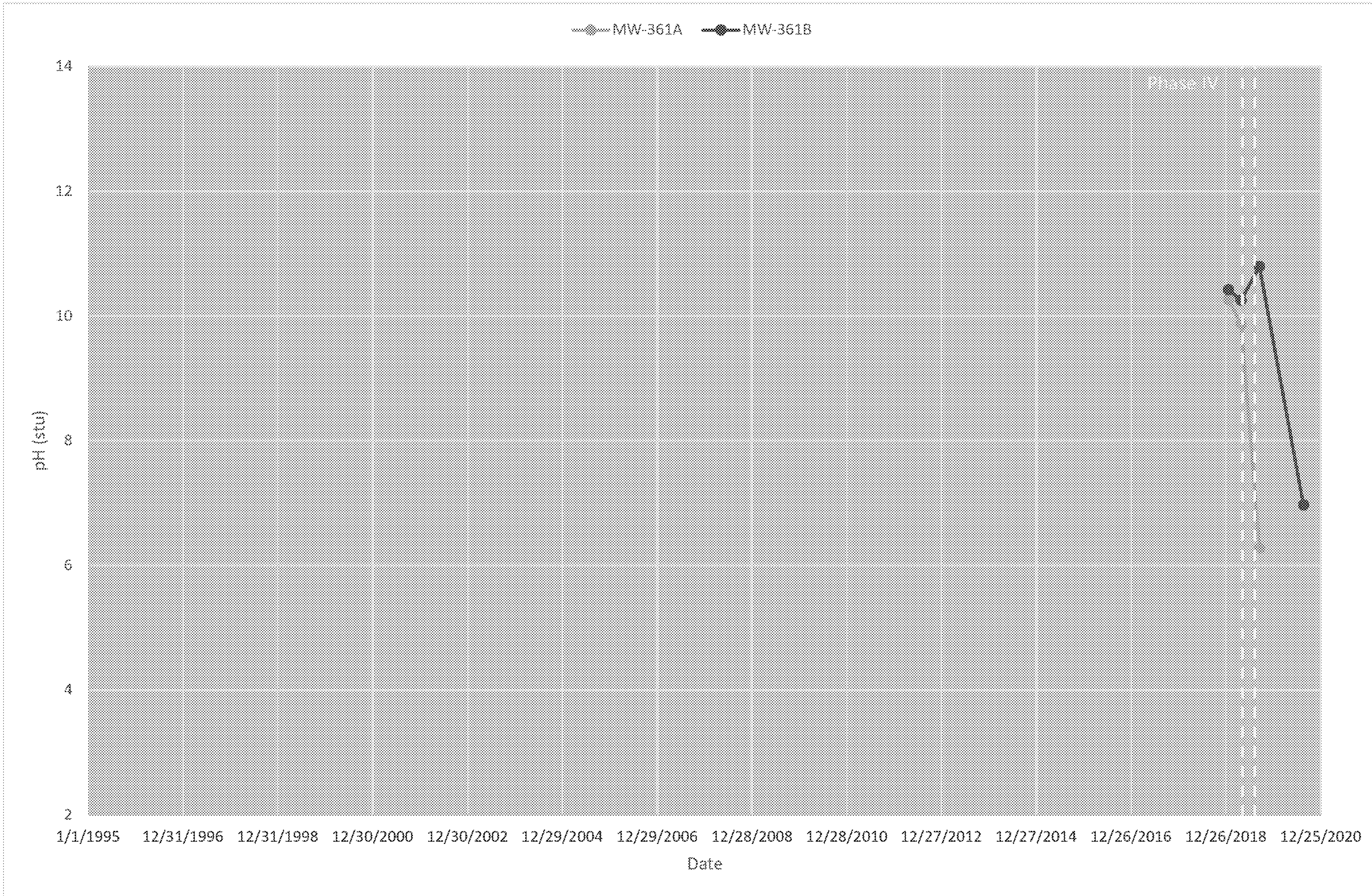
12/27/2014
12/26/2016
12/26/2018
12/25/2020
Date



MW-357A
MW-357B
Phase I-II
14
12
10
8
6
4
2
pH (stu)
1/1/1995
12/31/1996
12/31/1998
12/30/2000
12/30/2002
12/29/2004
12/29/2006
12/28/2008
12/28/2010
12/27/2012
12/27/2014
12/26/2016
12/26/2018
12/25/2020
Date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MW-361B
Phase IV
14
12
10
8
6
4
2
pH (stu)
1/1/1995
12/31/1996
12/31/1998
12/30/2000
12/30/2002
12/29/2004
12/29/2006
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12/28/2010
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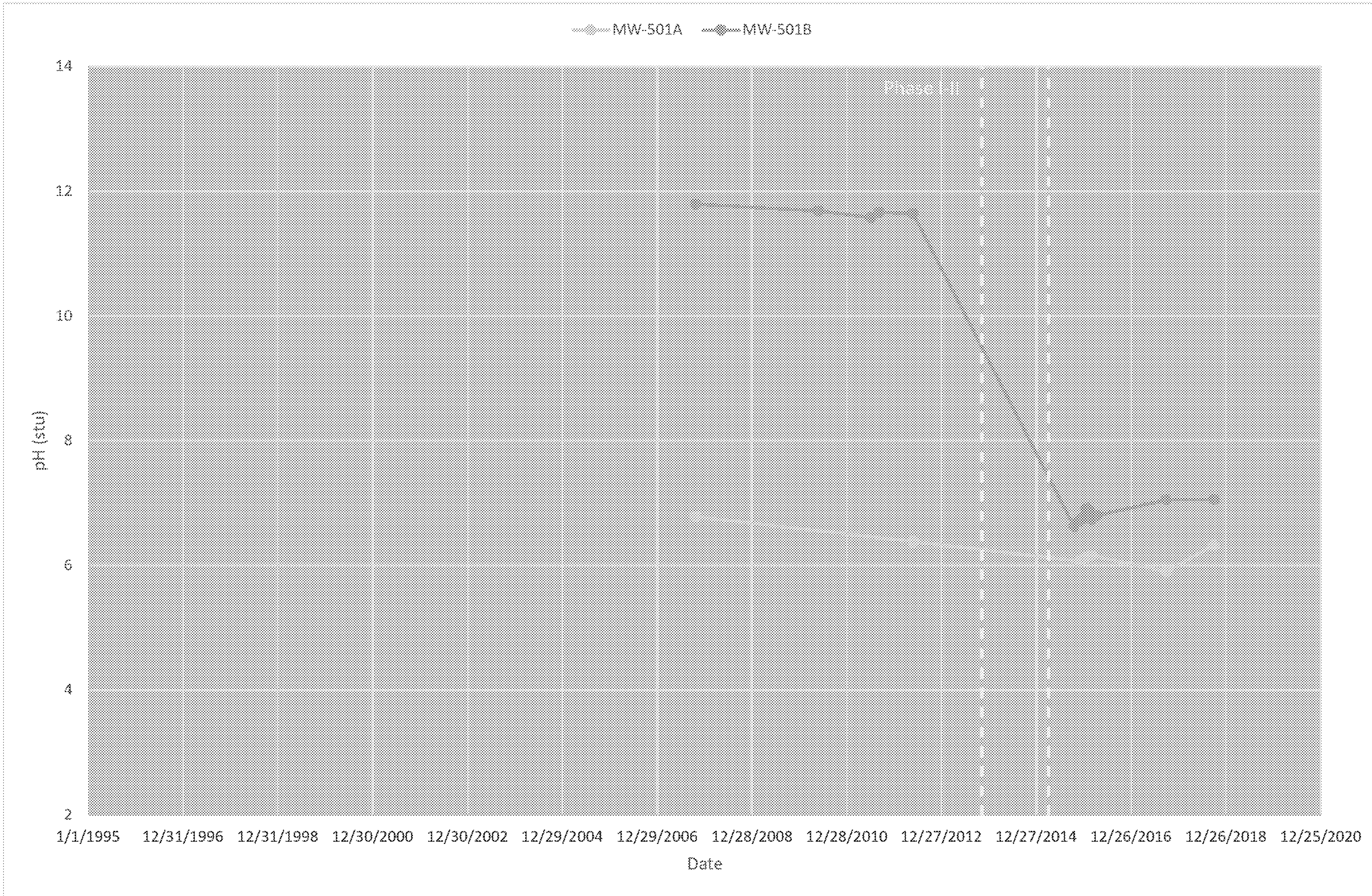
12/26/2016
12/26/2018
12/25/2020
Date



MW-501A
MW-501B
Phase I - II
pH (stu)
14
12
10
8
6
4
2
1/1/1995
12/31/1996
12/31/1998
12/30/2000
12/30/2002
12/29/2004
12/29/2006
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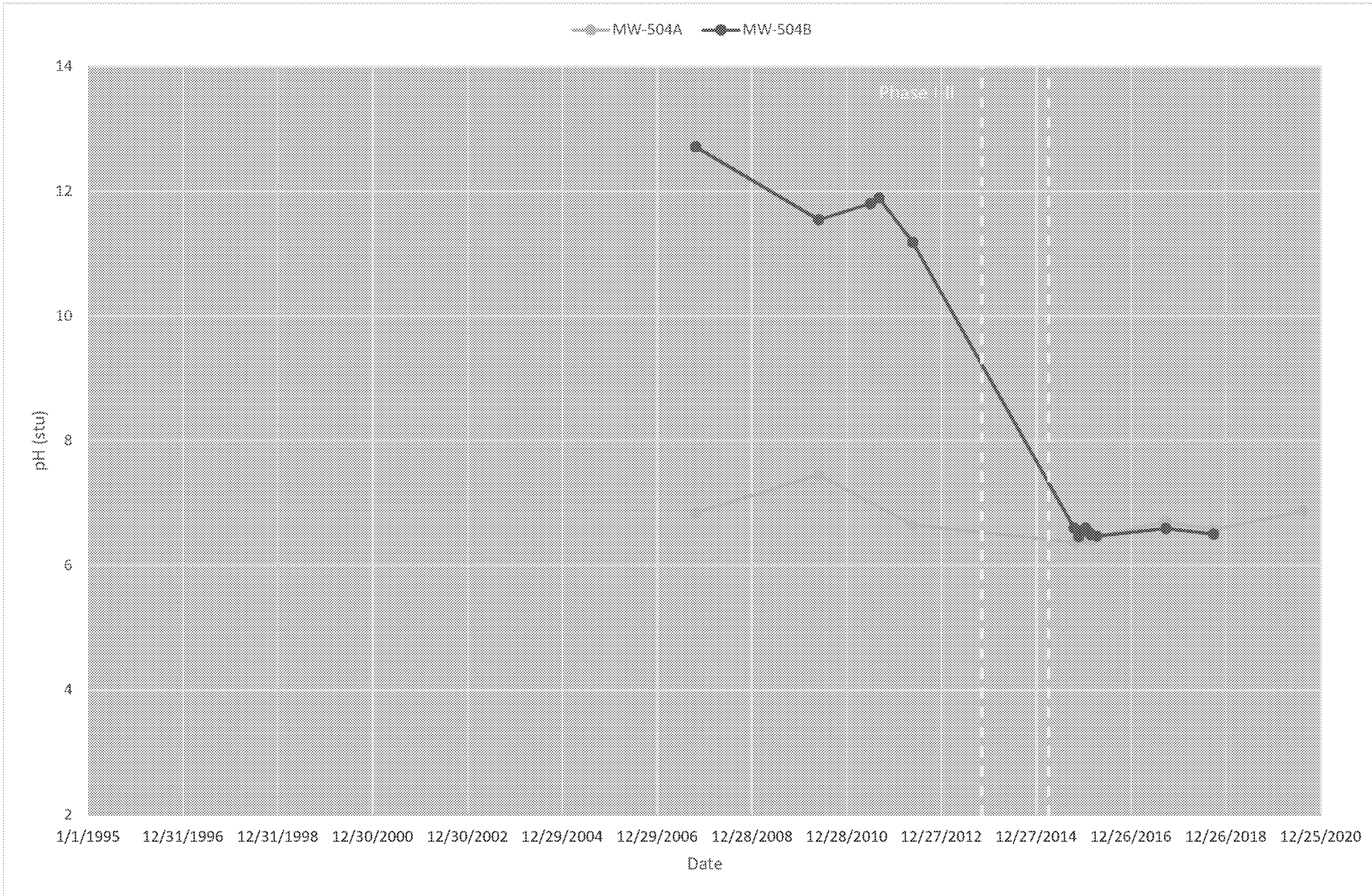
12/27/2014
12/26/2016
12/26/2018
12/25/2020
Date



MW-504A
MW-504B
Phase I-II
pH (stu)
14
12
10
8
6
4
2
1/1/1995
12/31/1996
12/31/1998
12/30/2000
12/30/2002
12/29/2004
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12/25/2020
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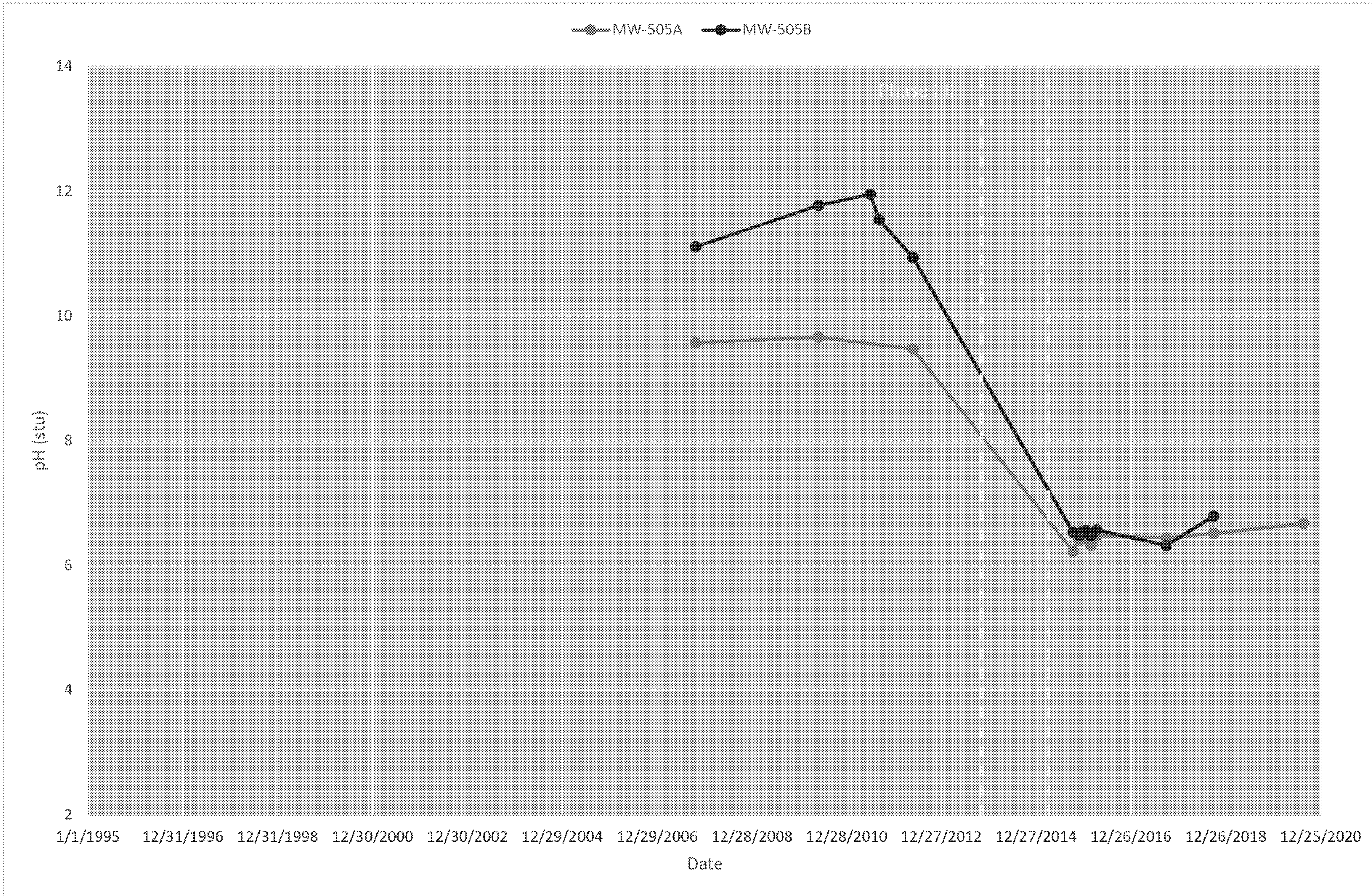
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MW-505B
Phase I-II
pH (stu)
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12
10
8
6
4
2
1/1/1995
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12/31/1998
12/30/2000
12/30/2002
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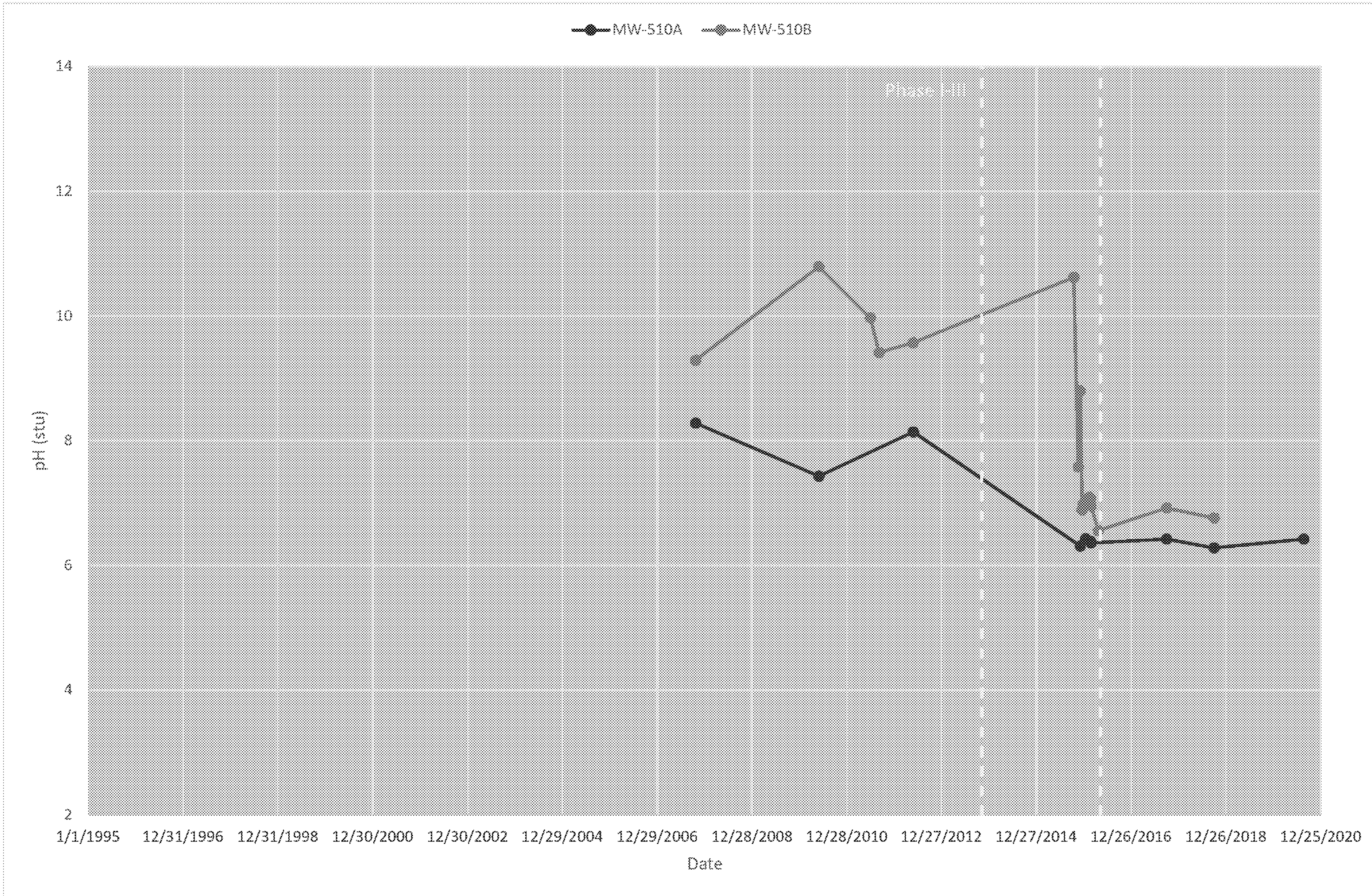

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MW-510B
14
12
10
8
6
4
2
pH (stu)
Phase I-III
1/1/1995
12/31/1996
12/31/1998
12/30/2000
12/30/2002
12/29/2004
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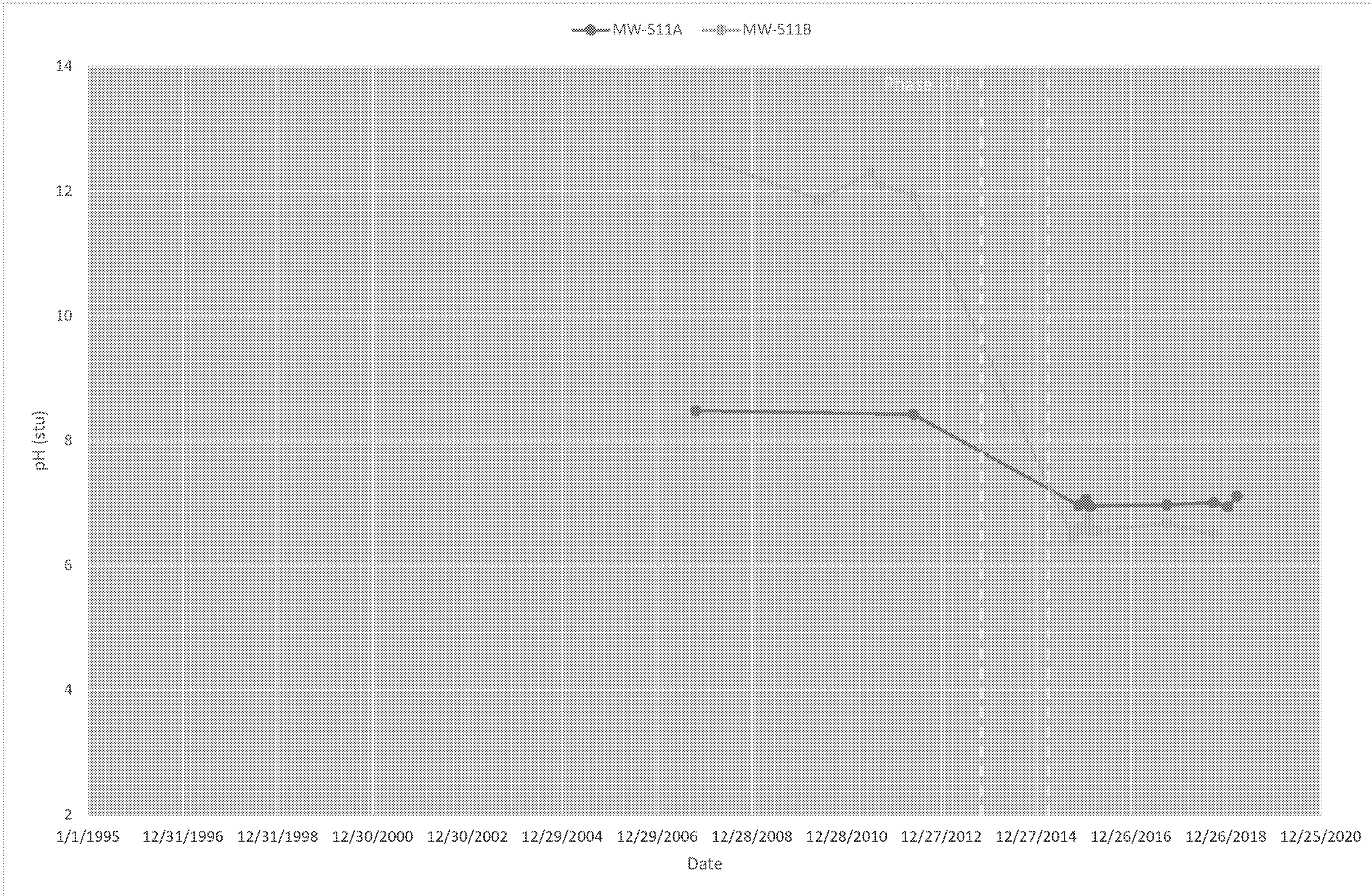

MW-511A
MW-511B
Phase I-II
pH (stu)
14
12
10
8
6
4
2
1/1/1995
12/31/1996
12/31/1998
12/30/2000
12/30/2002
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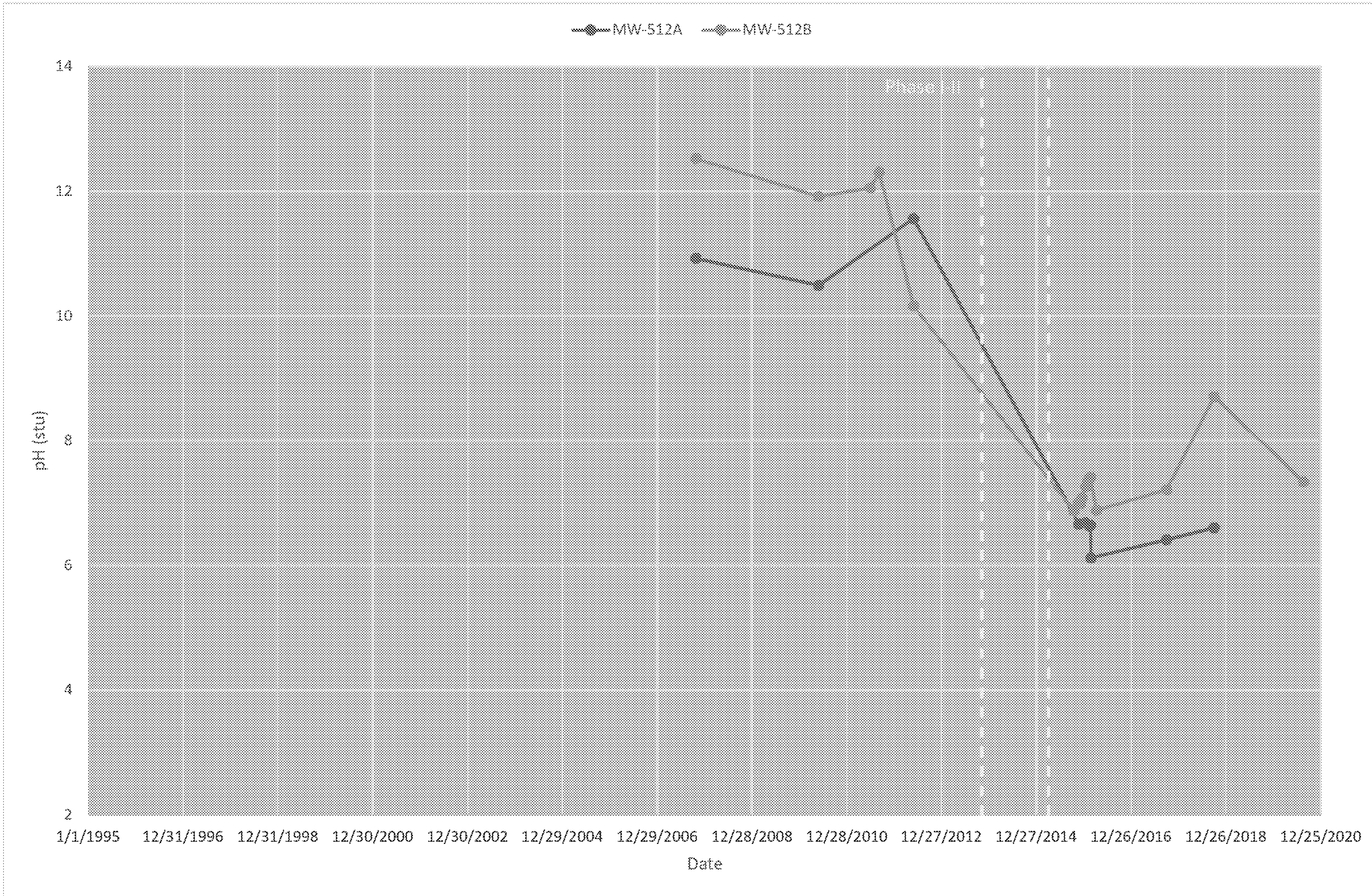
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Phase I-II
14
12
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8
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4
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pH (stu)
1/1/1995
12/31/1996
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12/30/2000
12/30/2002
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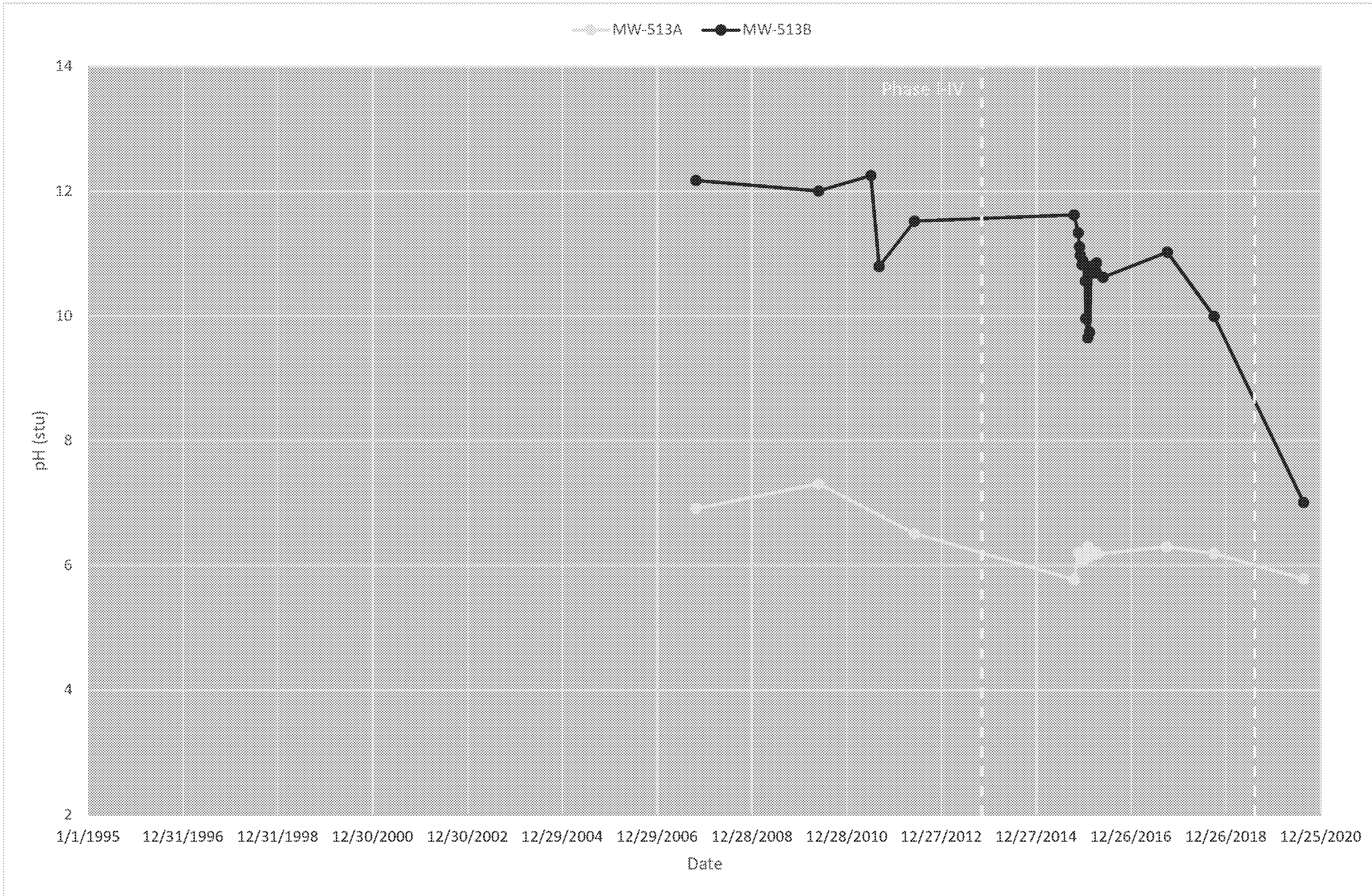

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MW-513B
Phase I-IV
pH (stu)
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12
10
8
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4
2
1/1/1995
12/31/1996
12/31/1998
12/30/2000
12/30/2002
12/29/2004
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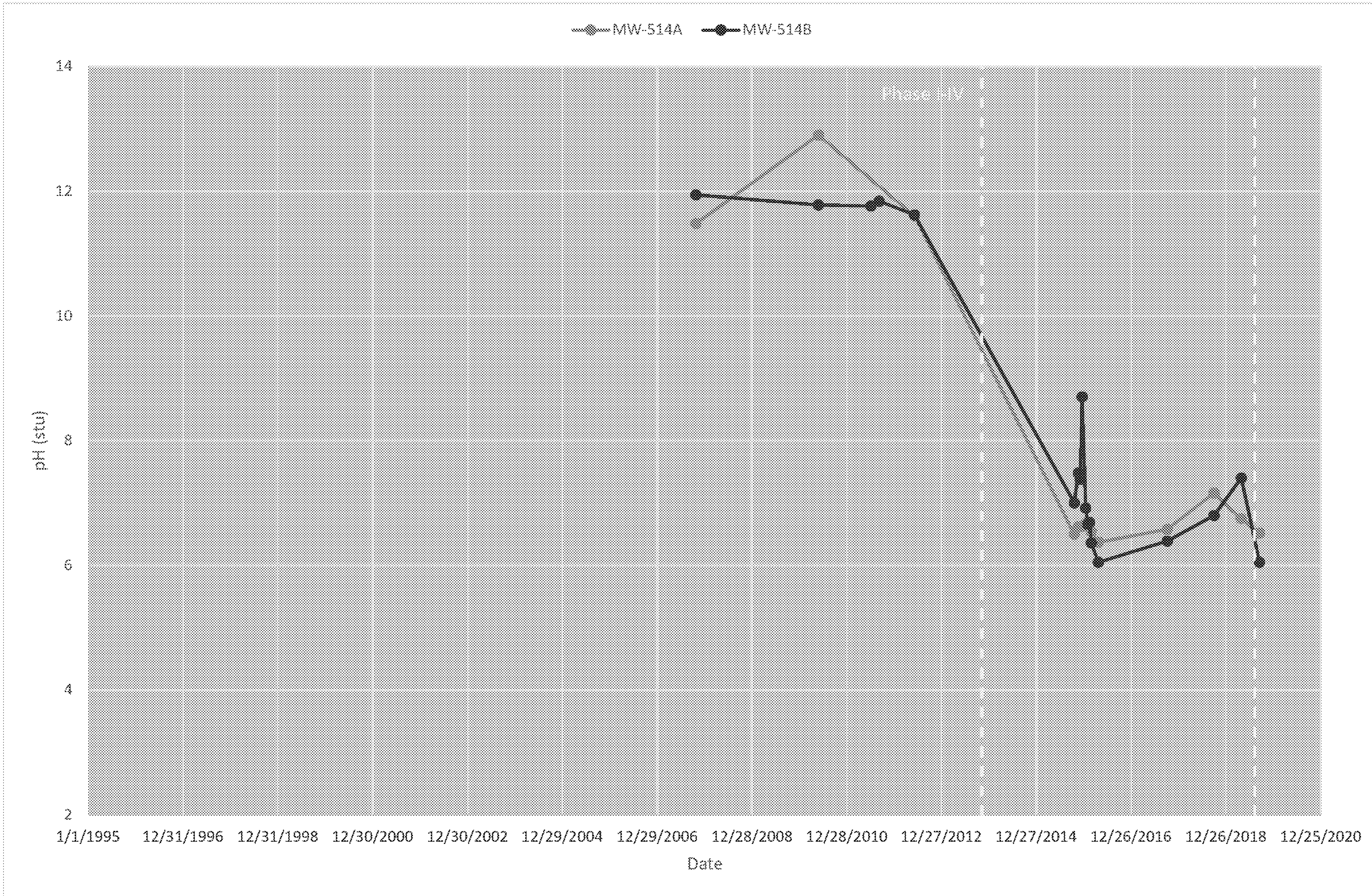

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MW-514B
Phase I-IV
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12
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pH (stu)
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12/31/1996
12/31/1998
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12/30/2002
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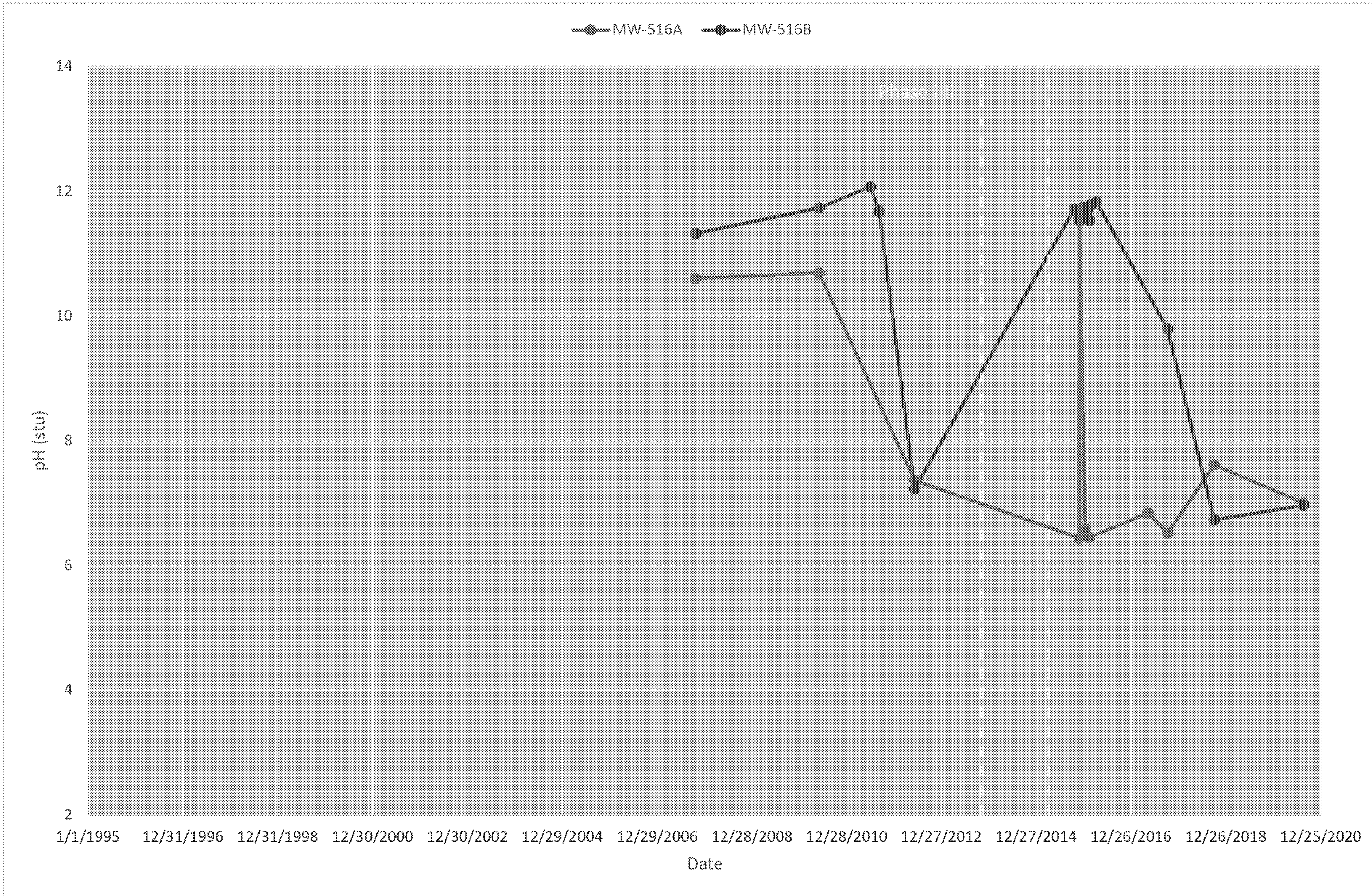

MW-516A
MW-516B
Phase I-II
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pH (stu)
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12/31/1998
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12/30/2002
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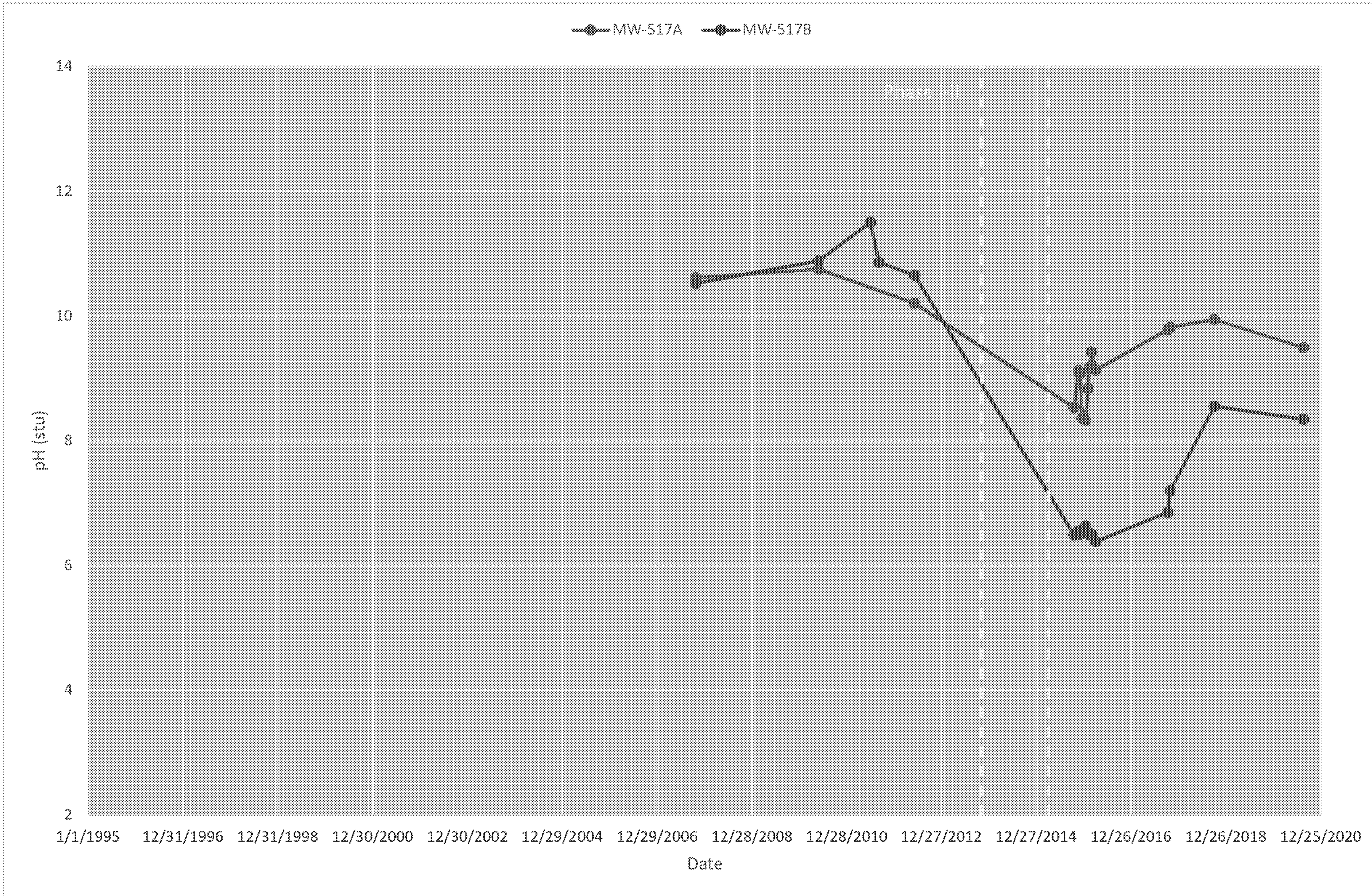

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MW-517B
Phase I-II
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6
4
2
pH (stu)
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12/31/1996
12/31/1998
12/30/2000
12/30/2002
12/29/2004
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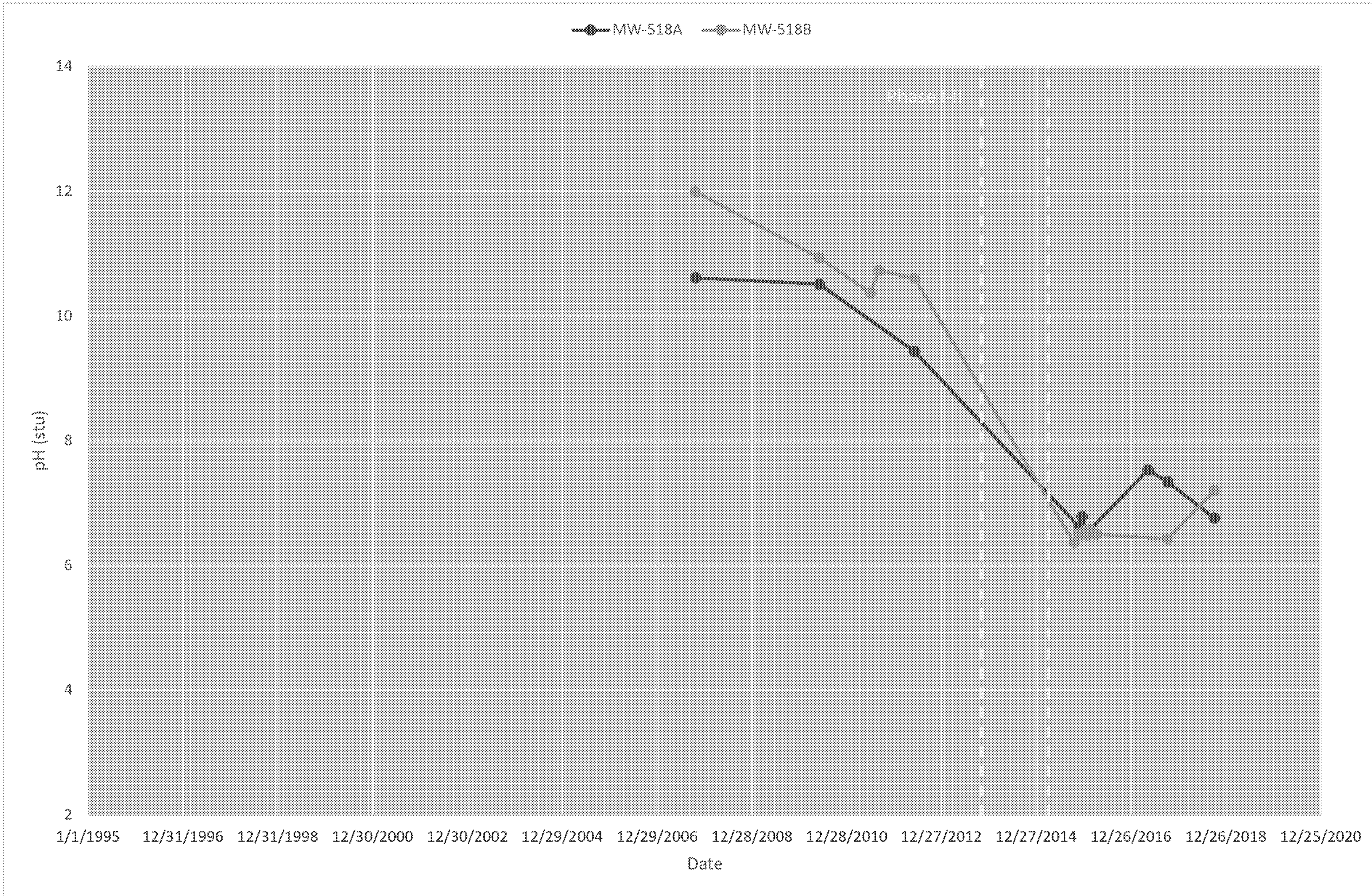
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MW-518B
Phase I-II
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8
6
4
2
pH (stu)
1/1/1995
12/31/1996
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12/30/2002
12/29/2004
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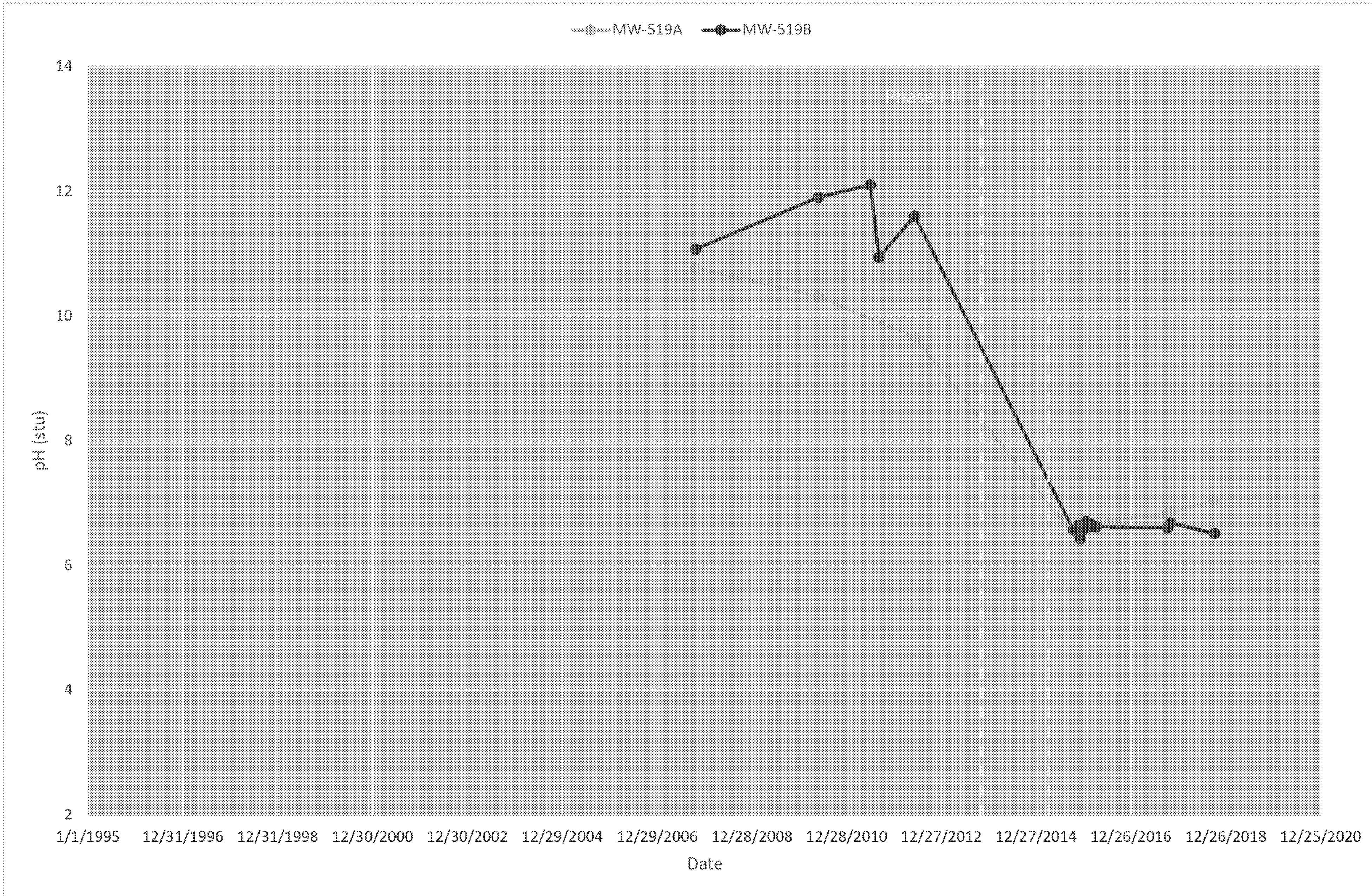

MW-519A
MW-519B
Phase I-II
pH (stu)
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12
10
8
6
4
2
1/1/1995
12/31/1996
12/31/1998
12/30/2000
12/30/2002
12/29/2004
12/29/2006
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12/25/2020
Date